

## DOE Hybrid Electric Vehicle Program

### Why HEVs?

Hybrid Electric Vehicles (HEV) combine the heat engine and fuel tank of a conventional vehicle with the battery and electric motor of an electric vehicle. This combination offers the extended range and rapid refueling that consumers expect from a conventional vehicle, with a significant portion of the energy and environmental benefits of an electric vehicle. The practical benefits of HEVs include improved fuel economy and lower emissions compared to conventional vehicles and the capability of using petroleum or alternative fuels. The inherent flexibility of HEVs will allow their use in a wide range of applications from personal transportation to commercial hauling.

### DOE Program goals

The U.S. Department of Energy (DOE) is working closely with other Federal agencies and key auto industry partners to develop HEVs as a practical way of providing clean and efficient transportation for the future that will significantly contribute to reducing our Nation's growing dependence on imported oil. HEV R&D is a key component of DOE's Advanced Automotive Technologies Program and is focused on two strategic goals:

1. Develop a production-feasible hybrid propulsion system by 1998 that will enable subsequent market introduction of a 50-mpg light-duty vehicle.
2. Develop production-feasible hybrid vehicle technologies by 2004 that will enable subsequent market introduction of an 80-mpg light-duty vehicle.

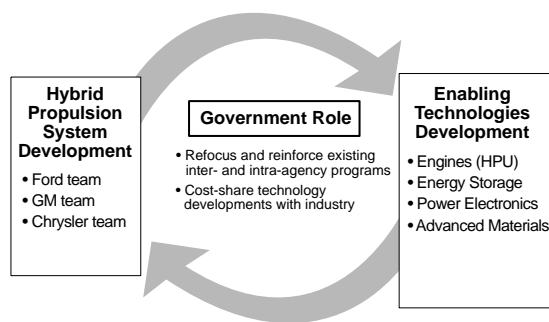
In support of these two goals, pre-competitive R&D is being conducted on critical and higher risk components and subsystems that can enhance HEV performance, reliability, and cost-effectiveness.

The 50-mpg and 80-mpg fuel economy targets represent two- and three-fold improvements over current six-passenger family sedans. In addition, the HEV technologies must meet Environmental Protection Agency Tier II light-duty emission standards; be acceptable to consumers with respect to performance, range, safety, and cost; and support the introduction of alternative fuels.

### HEV Program elements

The HEV Program is managed by DOE's Office of Transportation Technologies with technical program support from the National Renewable Energy Laboratory. The HEV

HEV Program Elements



Program currently consists of two major elements (see figure below).

*Hybrid Propulsion System Development* is focused on systems-driven development, system design, integration, and testing. This is a two-phased effort with the Phase I major milestone of 50-mpg capable hybrid propulsion system by 1998. Phase II, which will be initiated in the near future, will combine further advances in the hybrid propulsion system with other vehicle advances (in materials, etc.) to achieve the 80-mpg goal by 2004. In the first phase of the effort, DOE is supporting three versatile system development

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teams led by GM, Ford, and Chrysler through 50/50 cost-shared contracts. These teams have successfully mobilized the extensive internal resources of the three major automakers as well as that of key suppliers.

The propulsion system development teams are pursuing series and/or parallel hybrid configurations for combining engine-driven and electric propulsion, as well as a range of HPU (hybrid power unit) and advanced energy storage technologies. The GM and Ford teams, which have been under contract since 1993, have successfully progressed through the hybrid system definition and design phases. They will be initiating subsequent system build and test activities in 1996. Chrysler recently joined the HEV program in March 1996.

*Enabling Technologies Development* is focused on technologies that will ensure HEVs will be marketplace-acceptable. The key technologies are:

- Fuel-efficient, low-emission engines (gas turbine and four-stroke, direct-injection engine)
- High-power energy storage (battery, ultra-capacitor, and flywheel)
- Cost-effective, high-efficiency power electronics

The primary thrust is to improve the technical and/or economic performance of key technologies. A major challenge is to achieve a sizeable reduction in the manufacturing cost of the complete electric drivetrain. Major enabling R&D projects are:

- Ceramic gas turbine development and demonstration with Allison Engine Co. and AlliedSignal
- High-power battery and ultracapacitor development with the U.S. Advanced Battery Consortium
- Automotive flywheel system technology development with the Department of Defense's Advanced Research Projects Agency

- Power Electronic Building Blocks (PEBB) program with the Navy's Office of Naval Research
- Multiple R&D grants under the Small Business Innovative Research Program

## Potential national benefits

The successful introduction and marketplace acceptance of HEVs could provide a wide range of energy, environmental, and economic benefits to the Nation. DOE has projected that HEVs could begin to enter the marketplace around the turn of the century. Success in the marketplace would offer significant reductions in U.S. dependence on foreign petroleum, as well as carbon emissions and energy costs to consumers of automobiles.

## Government/industry partnership

The DOE HEV Program is a critical element of the Partnership for a New Generation of Vehicles (PNGV). This is an historic partnership between the Federal Government and USCAR, a consortium composed of the three major U.S. automakers. Consistent with the PNGV approach, the HEV Program maintains close coordination with other Federal agencies and the industry partners. Program personnel in the HEV program formally participate in the PNGV activities.

Hybrid propulsion has been identified as a core technology that is a priority candidate for achieving the PNGV goal of tripling automobile fuel economy. Achieving this goal requires close integration of HEV propulsion technology advances with enabling technology advances and developments in other areas such as lightweight materials, aerodynamics, accessories, and manufacturing technologies.

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